*Second Annual*

**Climate Change Research Conference**

*And*

*First Scientific Conference*

**West Coast Governor's Global Warming Initiative**

***September 14-16, 2005 Sacramento, California***

# Opportunities for Terrestrial Carbon Sequestration in the West


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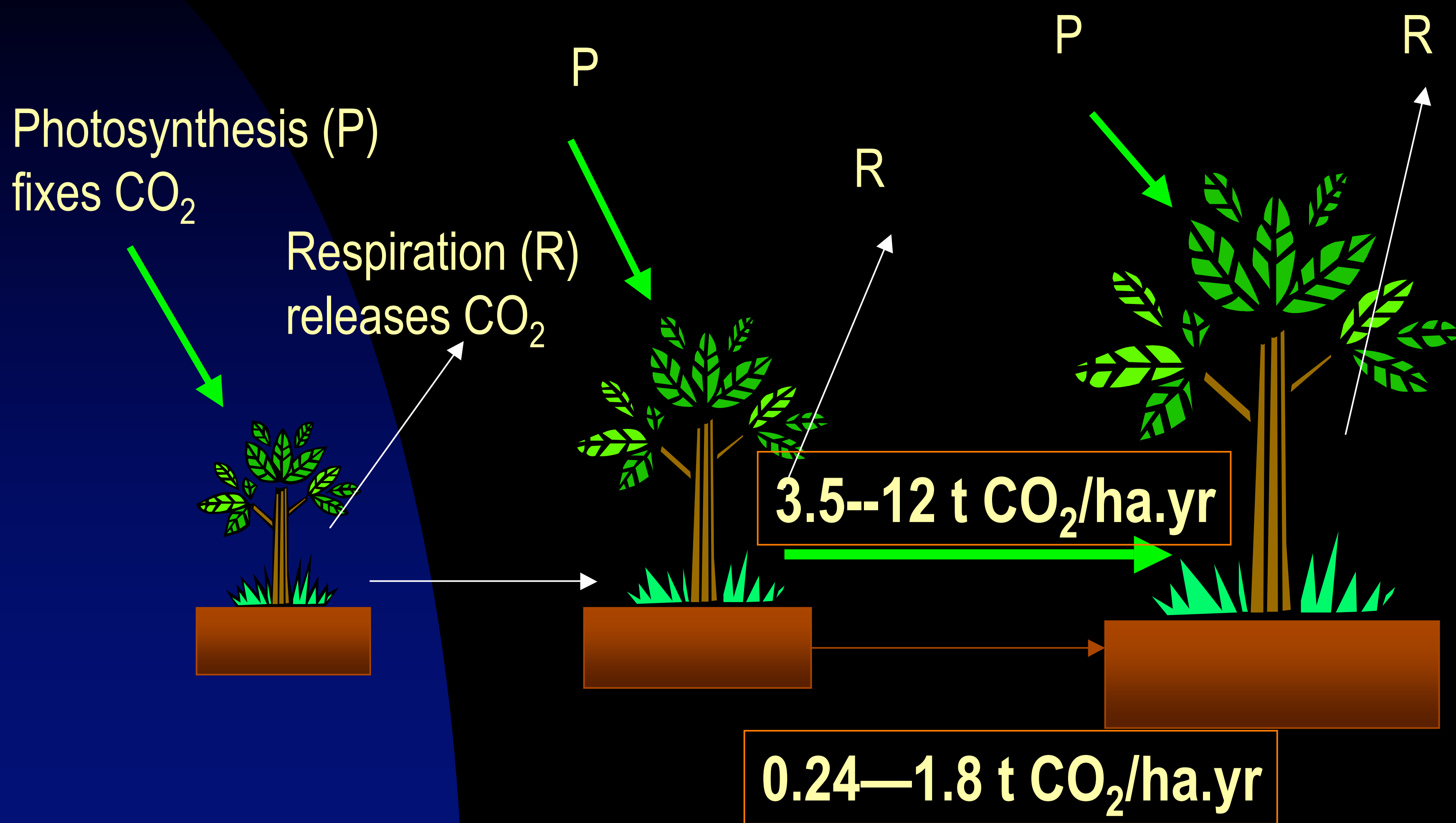
Nick Martin and Aaron Dushku
Winrock International

# Summary

- Overview
- Carbon supply from afforestation of ag and range
  - Oregon, Washington, and California
- Carbon supply from changing management of forest lands
  - Extend rotations
  - Protect riparian zones
  - Reduce risk of uncharacteristically severe fire
- Plans for data collection in Shasta County

# How Do Ecosystems Sequester Carbon?

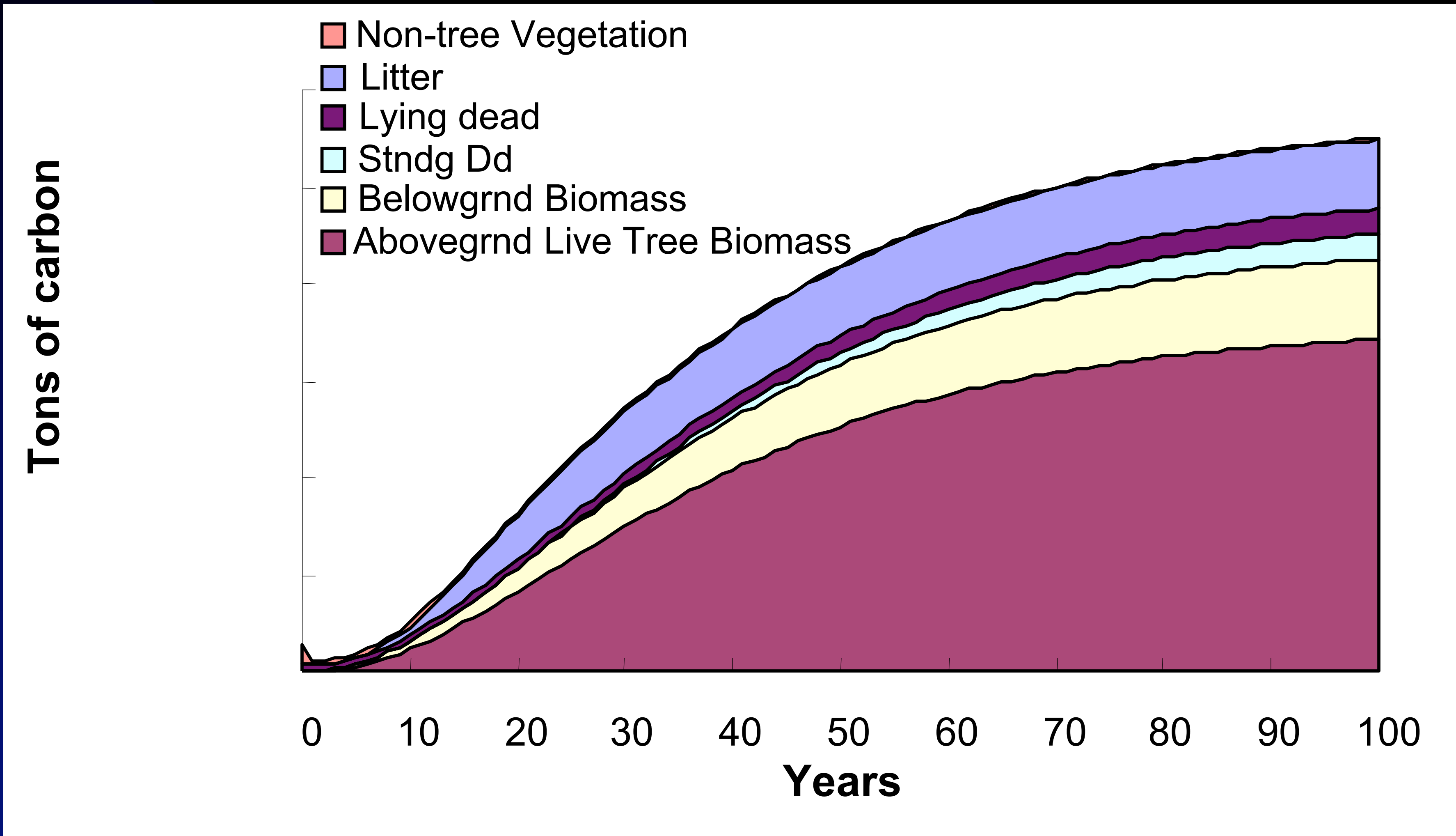


# Where is Carbon Sequestered?

- Live biomass
  - Trees
  - Understory
  - Roots
- Dead biomass
  - Standing
  - Down
    - Coarse
    - Fine
- Wood products
- Soil

"Carbon Pools"

# Carbon Accumulation



# General Approach for Carbon Supply

- Divide lands into three main categories:
  - Rangelands
  - Forests
  - Agriculture
- Identify options for enhancing carbon sequestration for each category
- Estimate:
  - Area available—how much and where
    - Spatial modeling and FIA data base
  - Amount of carbon sequestration over 20, 40, and 80 year periods
  - Costs (opportunity costs, conversion costs, maintenance costs, and measuring costs)

# Primary Findings

- Afforestation provides the largest terrestrial sequestration opportunity for Oregon, Washington, and California
- Large areas of grazing land suitable for afforestation can be found in each state
- Changes in management practices on forest lands can sequester additional carbon but the amounts are small and relatively expensive
- Potential sequestration from changing fire management practices on forest lands warrants additional data collection and analysis
- Although limited, some unique forest conservation opportunities are present in each state

# Afforestation

- Convert agricultural or grazing land back to forest
  - Return to native forest
  - Convert to forest


Mixed Conifers

# Conserve Forests

Photo: Tim Pearson, Winrock International

- Stop forest conversion to non-forest
- Sierra Mixed Conifer (150 year old forest)
  - 575 $tCO_2$/acre
- Redwood (150 year old forest)
  - 730 $tCO_2$/acre

Photo from Union Lumber Company Collection, Andrews 1965

# Data and Methods

- Where possible, same primary data sources and methods were used for each state
- California had more detailed land use change data

# California Results

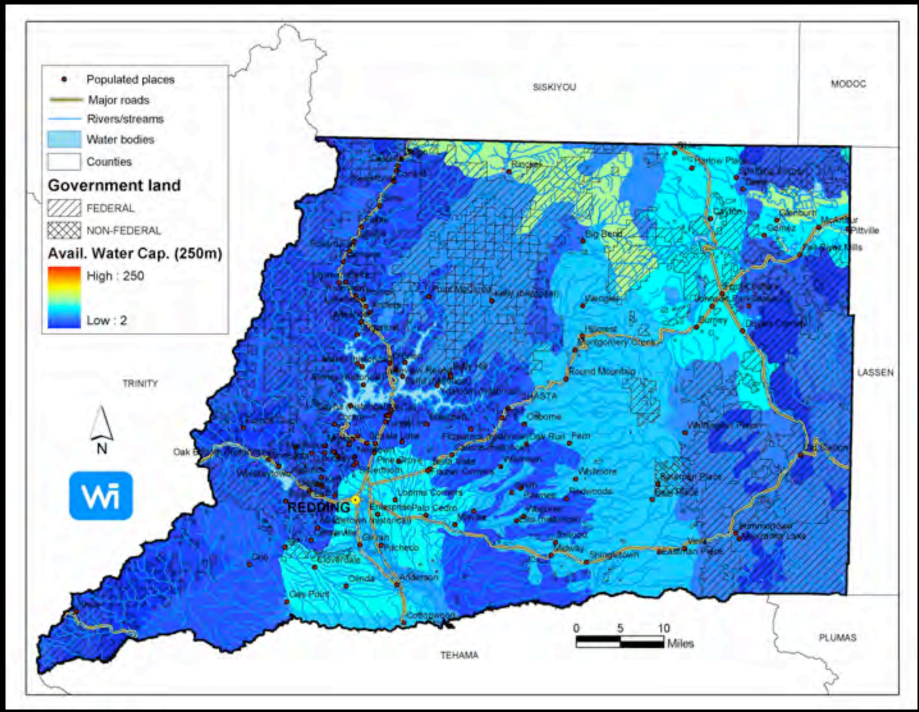
| Activity | Quantity—MMT $CO_2$ | | | Area available—M acres | | |
|---|---|---|---|---|---|---|
| | 20 yr | 40 yr | 80 yr | 20 yr | 40 yr | 80 yr |
| **Forest management** | | | | | | |
| Lengthen rotation | | | | | | |
| <$13.6 | **2.2-3.5** | -- | -- | 0.31 | -- | -- |
| Increase riparian buffer-width | | | | | | |
| <$13.6 | **3.91** (permanent) | | | | 0.044 | |
| **Grazing lands** | | | | | | |
| Afforestation | | | | | | |
| <$13.6 | **887** | 3,256 | 5,639 | 12.03 | 17.79 | 20.76 |
| <$2.7 | 33 | 1,610 | 4,569 | 0.20 | 5.68 | 13.34 |

# Emissions and Removals by Cause of Change for California

| MMTCO2/yr | Forests | Rangelands |
|---|---|---|
| Fire | -1.55 | -0.14 |
| Harvest | -1.40 | -0.03 |
| Development | -0.01 | -0.004 |
| Other/Unverified | -0.79 | -0.10 |
| Regrowth | +10.96 | +0.46 |

# Further Work Underway in California to Validate State Analysis

- Refine canopy cover:biomass relationships
- Estimate carbon in understory fuel loads
- Measure baseline carbon stocks in rangelands
- Estimate non-$CO_2$ GHG emissions




Additional field and aerial data is being collected.

# Why Shasta County?

- Diverse land cover representative of many areas across the state
- Opportunities for implementation of important classes of project opportunities
  - Afforestation and reforestation
    - Rangelands
    - Degraded lands
    - Riparian zones
  - Changes in forest management
    - Conservation
    - Reducing hazardous fuels
    - Lengthening rotations

# *Rangelands*

# Identify Rangelands Suitable for Conversion to Forests

- Analyze the relationship between existing forests and several biophysical factors using GEOMOD ="suitability for forest map"
- Cross-reference suitability map to areas of current rangelands to select areas with afforestation potential.

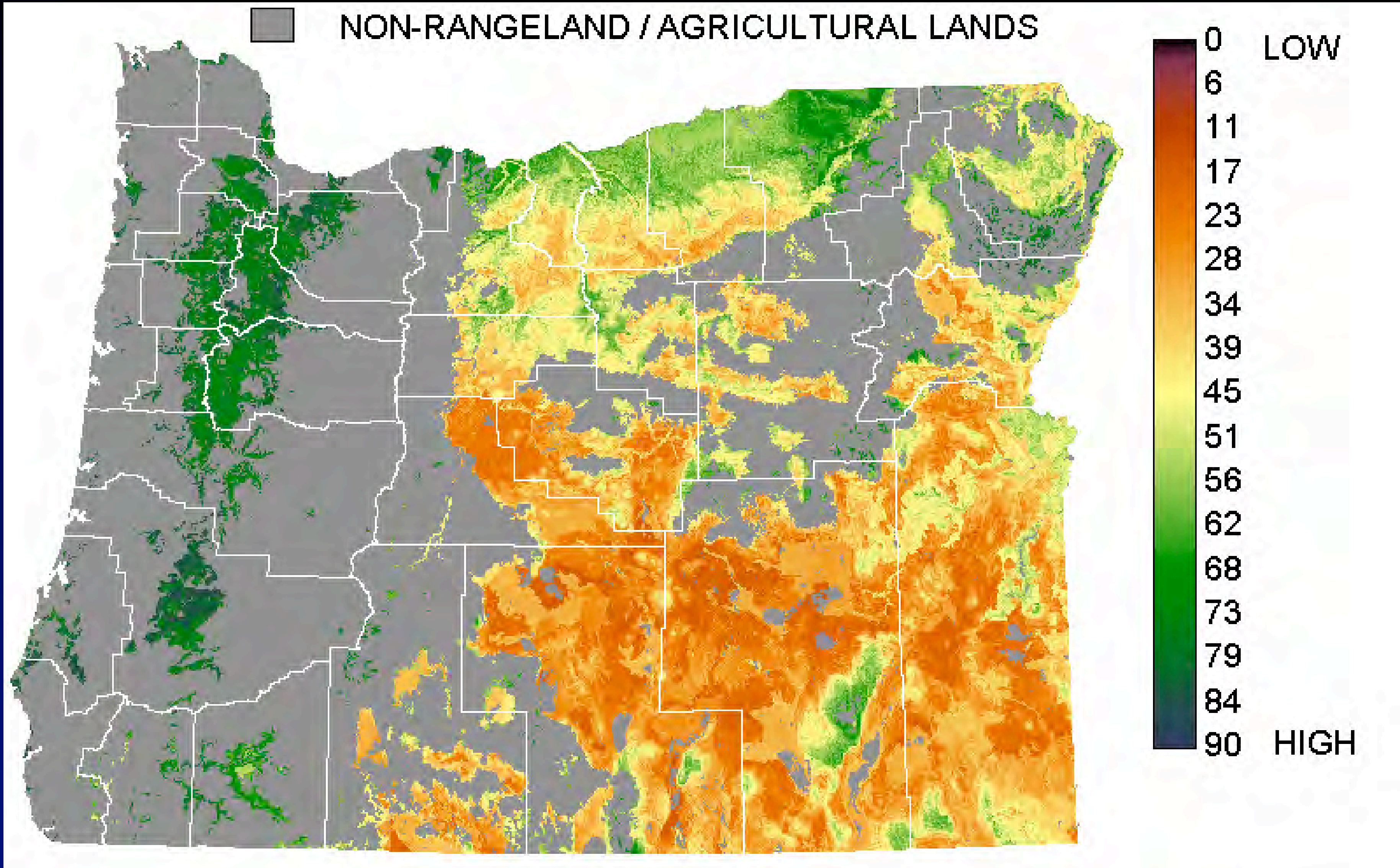
  ***Product = map of rangeland areas suitable to support forests***
- Carbon sequestration in forest biomass derived from FIA and literature

  ***Product = map of carbon accumulation for afforesting rangelands***

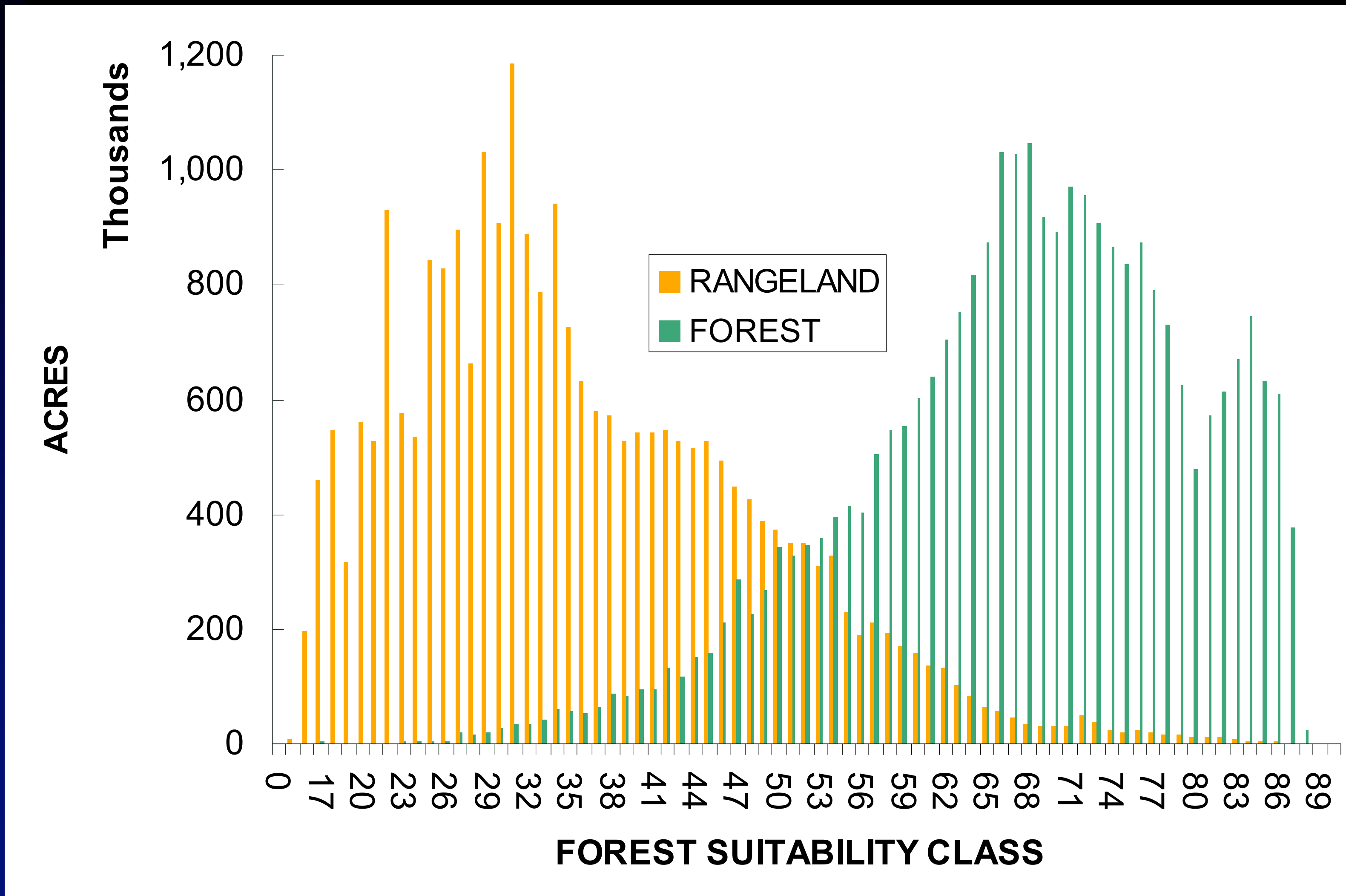
# Combine Factor Maps to Determine Suitability for Afforestation

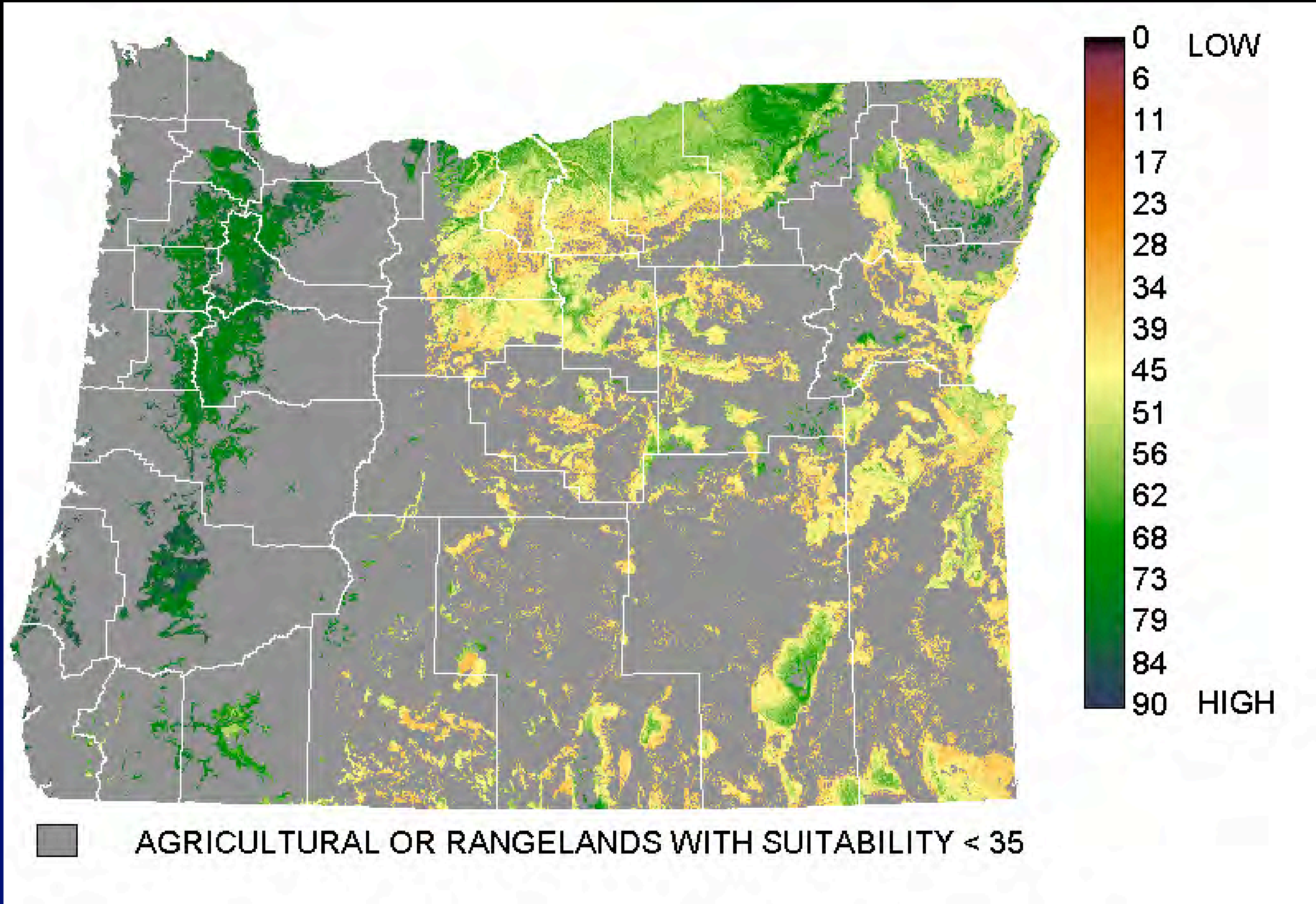
- Slope
- Elevation
- Mean annual temperature
- Mean annual precipitation
- Available water capacity

# Agricultural and Grazing Lands Suitable for Afforestation

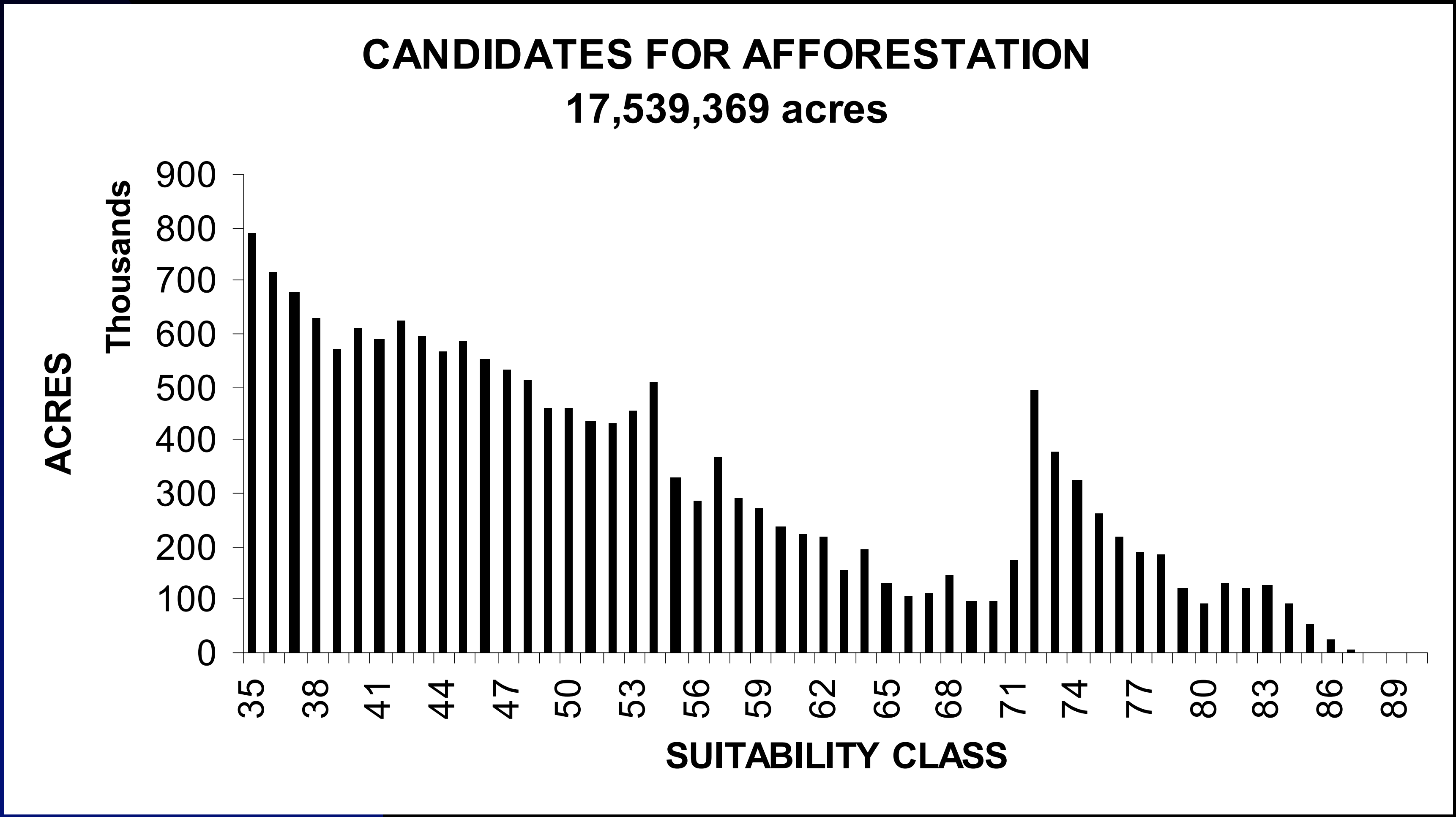


# Suitability for Forest versus Rangeland

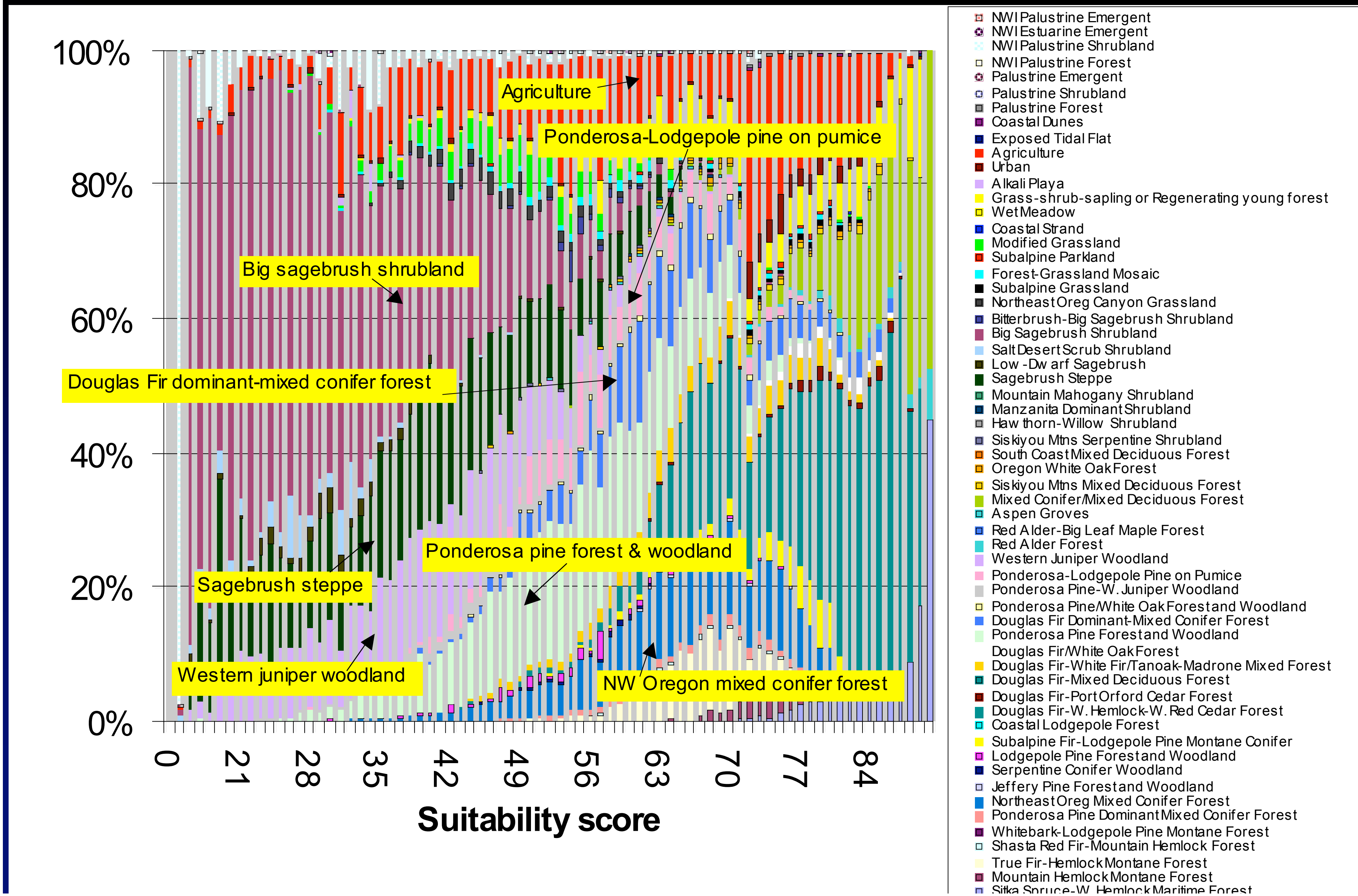



0 LOW
6
11
17
23
28
34
39
45
51
56
62
68
73
79
84
90 HIGH
AGRICULTURAL OR RANGELANDS WITH SUITABILITY < 35

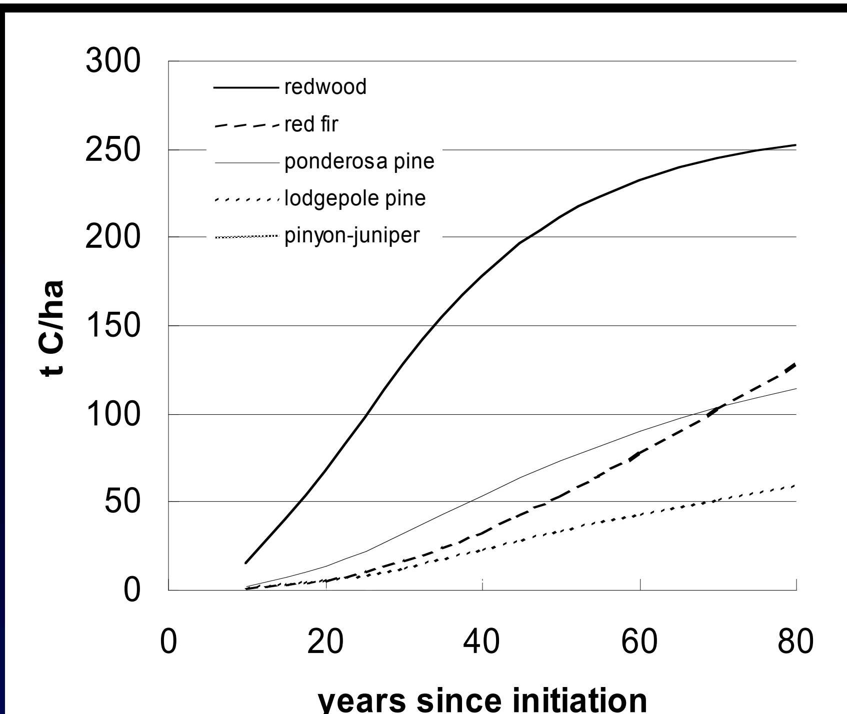
# Potential Afforestation Area

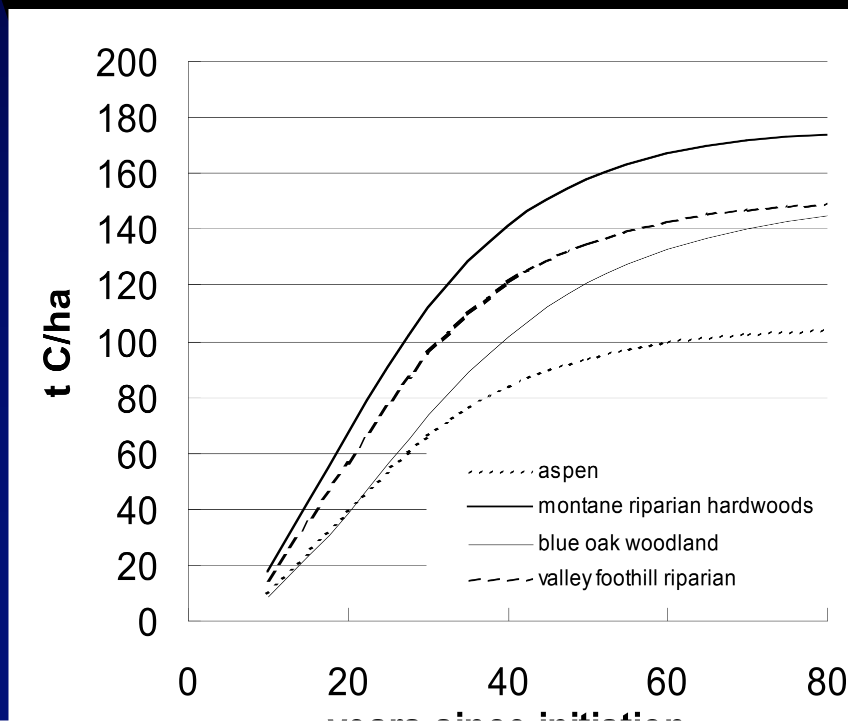


# Species Mix for Various Suitability Scores



# Potential Carbon Accumulation in Conifer and Hardwood Forests

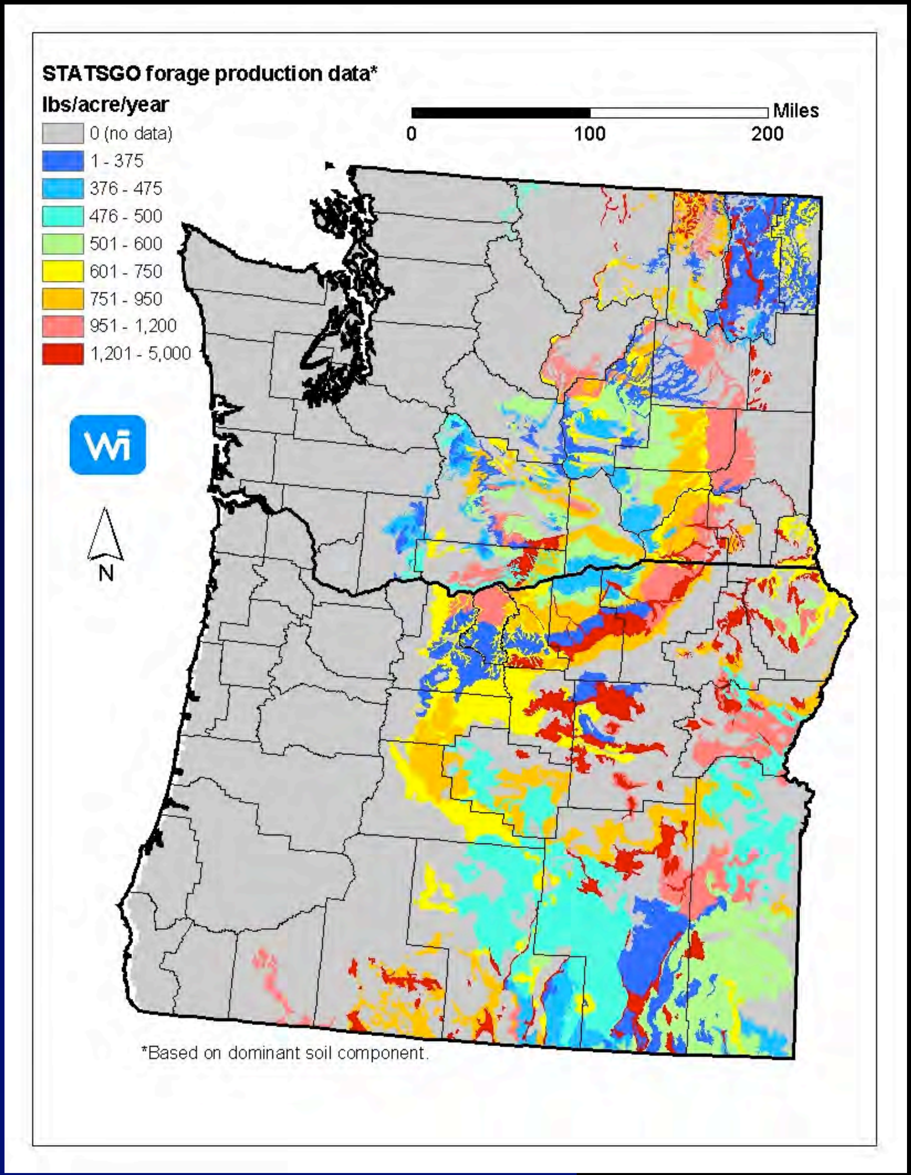


# Cost of Carbon Sequestration

- Opportunity costs:
  - Using the same biophysical factors, a multivariate model was used to extrapolate STATSGO forage productivity data samples to a state-wide coverage.

    ***Product = map forage production***
  - Economic analysis of forage value derived from national databases and field interviews
    - Mean annual profit/cow
    - Number of cows supported based strongly on forage production (1 animal unit month for CA = 791 lbs)



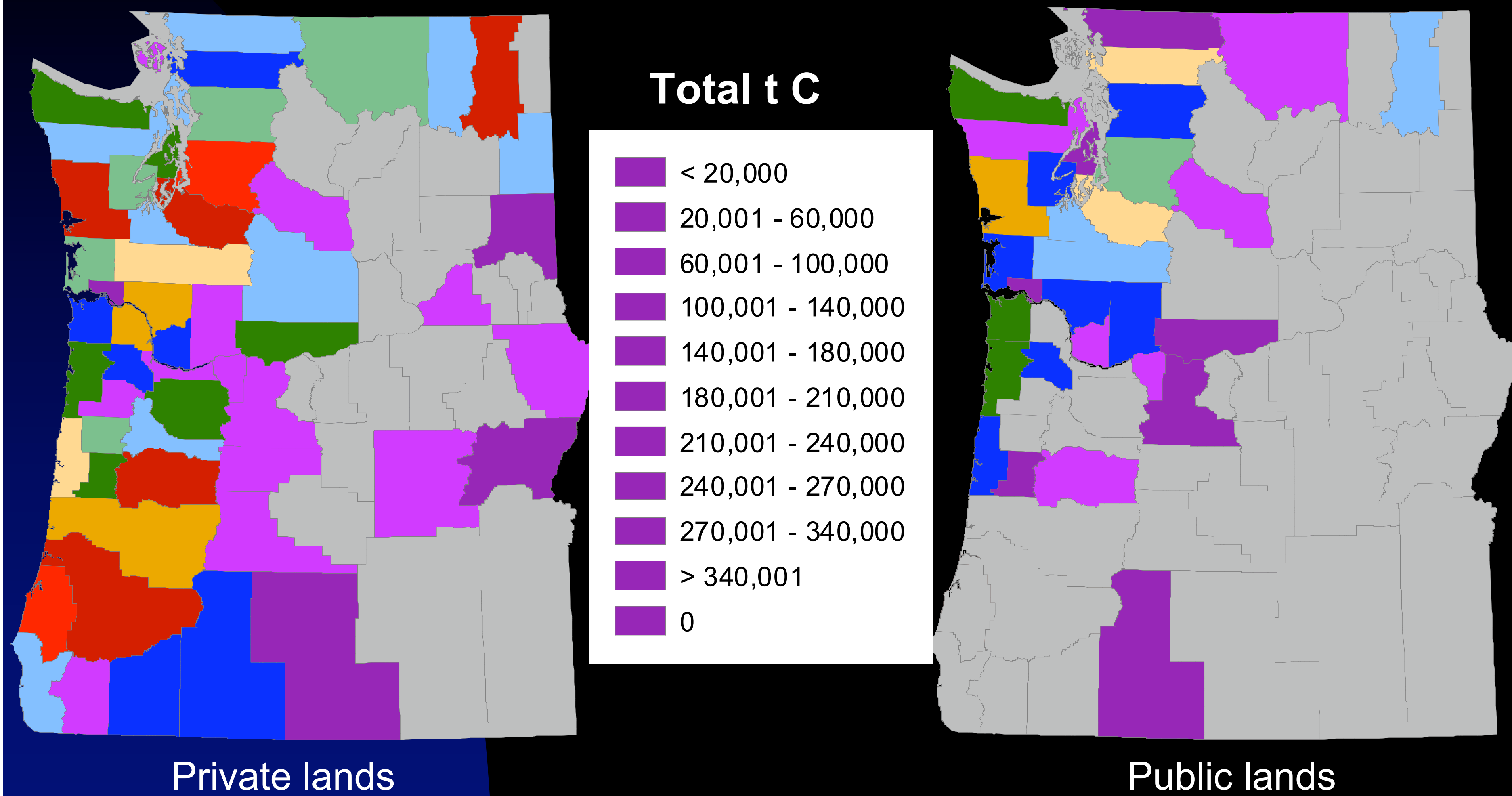

Forage production potential is used to determine the opportunity cost for various classes of rangeland

# *Forests*

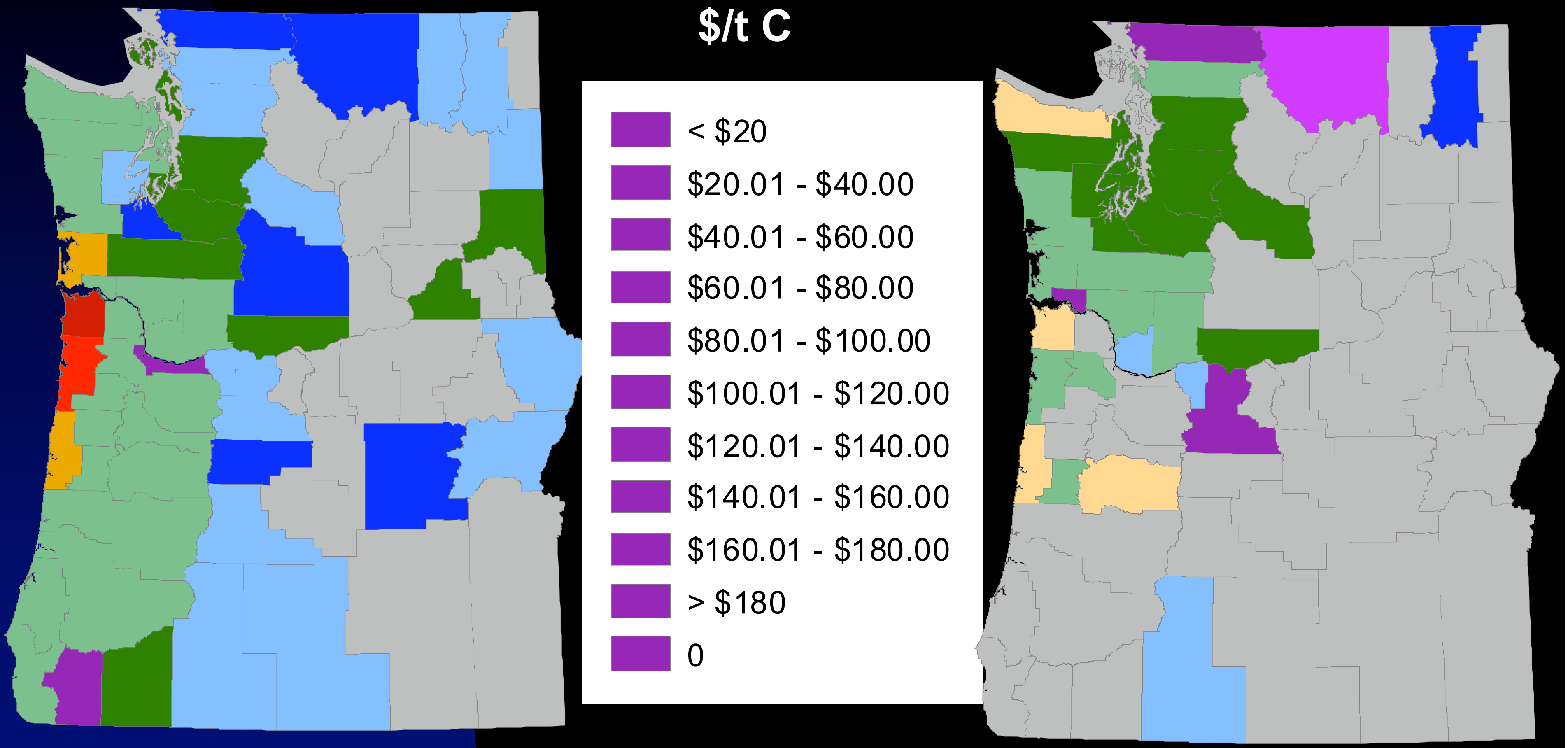
# Three alternatives analyzed:

- Estimates were derived for permanent contract periods:
  - ✓ (1) allowing timber to age, i.e. lengthening rotation time 5, 10 and 15 years (only forests nearing optimal age for harvest are considered);
  - ✓ (2) creating a riparian buffer zone of 200 feet;
  - ➢ (3) forest fuel reduction to reduce hazard of catastrophic fires, and subsequent use of biomass in power plants

# Extending Rotations by 5 years



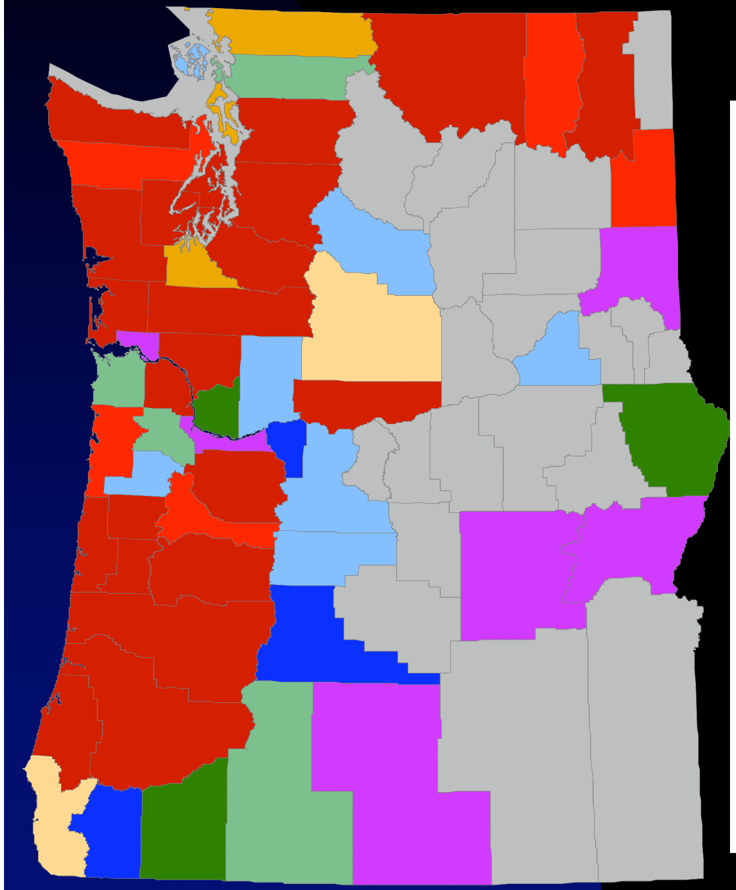
# Cost for Carbon Supply from Extending Rotation 5 Years




Private lands

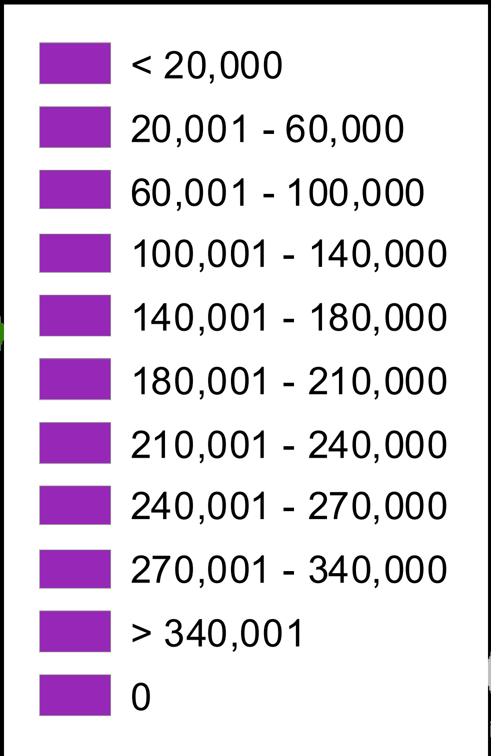
Public lands

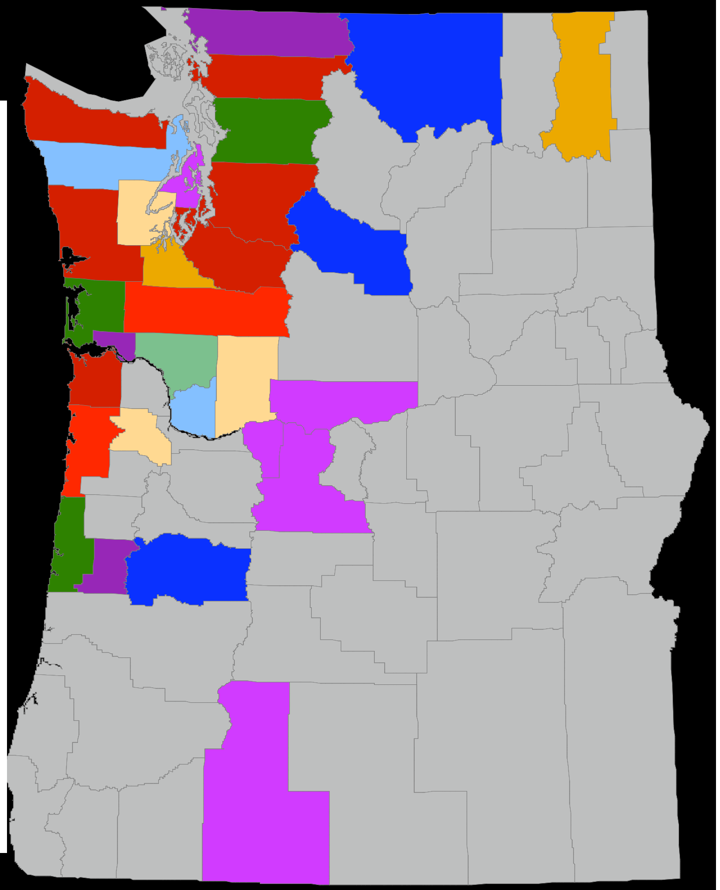
# Extending rotation 15 years



Private lands

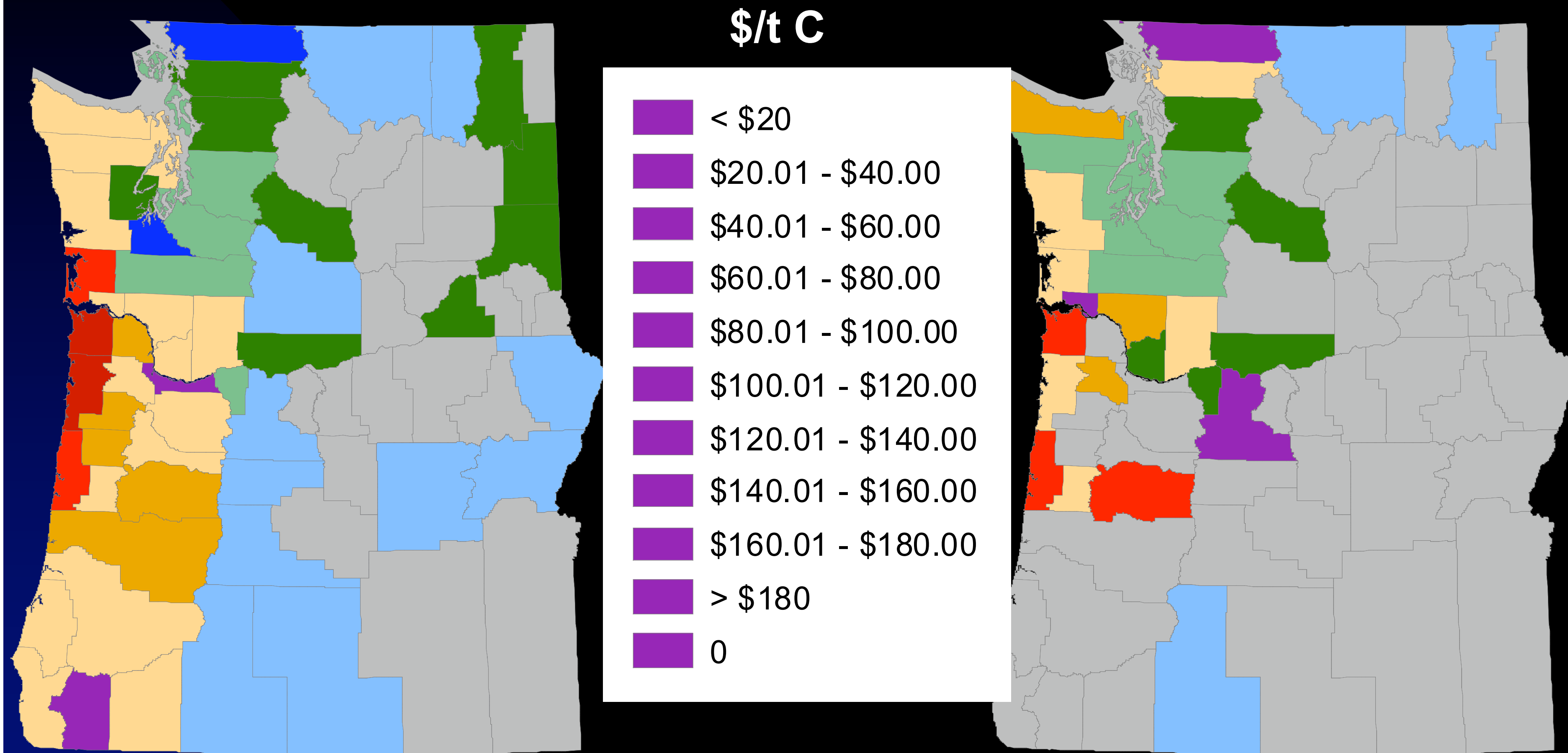
Total t C



Public lands

# Cost for Carbon Supply from Extending Rotation 15 Years




Private lands

Public lands

| Oregon | Extending Rotations | | |
|---|---|---|---|
| | 5 yr. | 10 yr. | 15 yr. |
| **Private Land Potential Hectares** | **283,670** | | |
| Million Tons C | 3.6 | 6.3 | 8.4 |
| Million $$ | $394 | $787 | $1,150 |
| Average $$ per ton | $111 | $125 | $136 |
| Average $$ per hectare | $1,388 | $2,775 | $4,053 |
| Average Tons per hectare | 12.5 | 22.2 | 29.7 |
| | | | |
| **Public Land Potential Hectares[1]** | **36,368** | | |
| Million Tons C | 0.6 | 1.0 | 1.3 |
| Million $$ | $63 | $129 | $193 |
| Average $$ per ton | $111 | $125 | $136 |
| Average $$ per hectare | $1,735 | $3,544 | $5,304 |
| Average Tons per hectare | 15.4 | 27.4 | 36.7 |

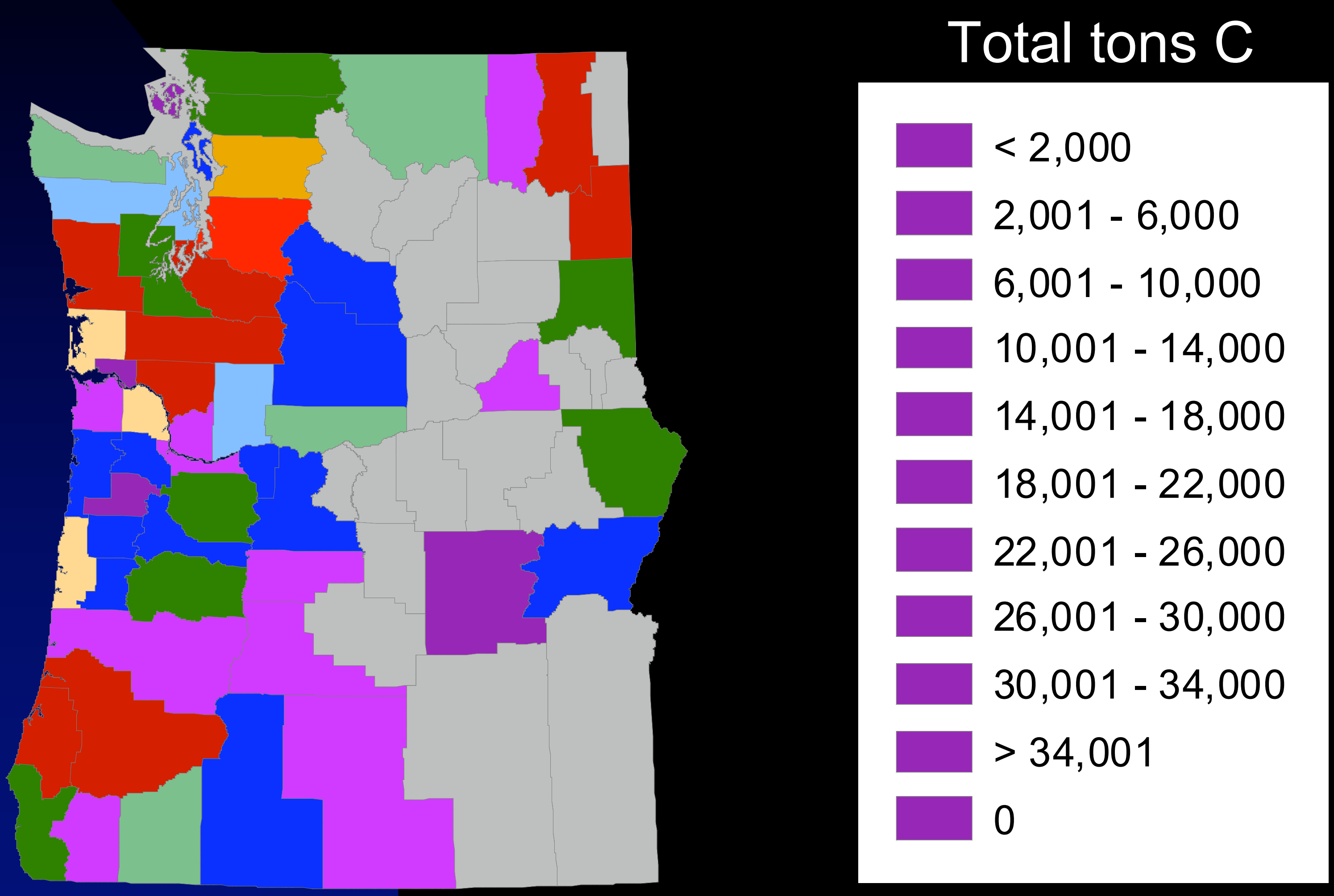
[1] Note that public land omits Federal USDA Forest Service lands.

| Washington | Extending Rotations | | |
|---|---|---|---|
| | 5 yr. | 10 yr. | 15 yr. |
| **Private Land Potential Hectares** | **443,665** | | |
| Million Tons C | 5.1 | 9.0 | 12.0 |
| Million $$ | $460 | $894 | $270 |
| Average $$ per ton | $111 | $125 | $136 |
| Average $$ per hectare | $1,036 | $2,014 | $2,862 |
| Average Tons per hectare | 11.5 | 20.3 | 27.0 |
| | | | |
| **Public Land Potential Hectares[1]** | **147,625** | | |
| Million Tons C | 2.0 | 3.6 | 4.8 |
| Million $$ | $203 | $394 | $564 |
| Average $$ per ton | $111 | $125 | $136 |
| Average $$ per hectare | $1,378 | $2,672 | $3,820 |
| Average Tons per hectare | 13.8 | 24.2 | 32.3 |

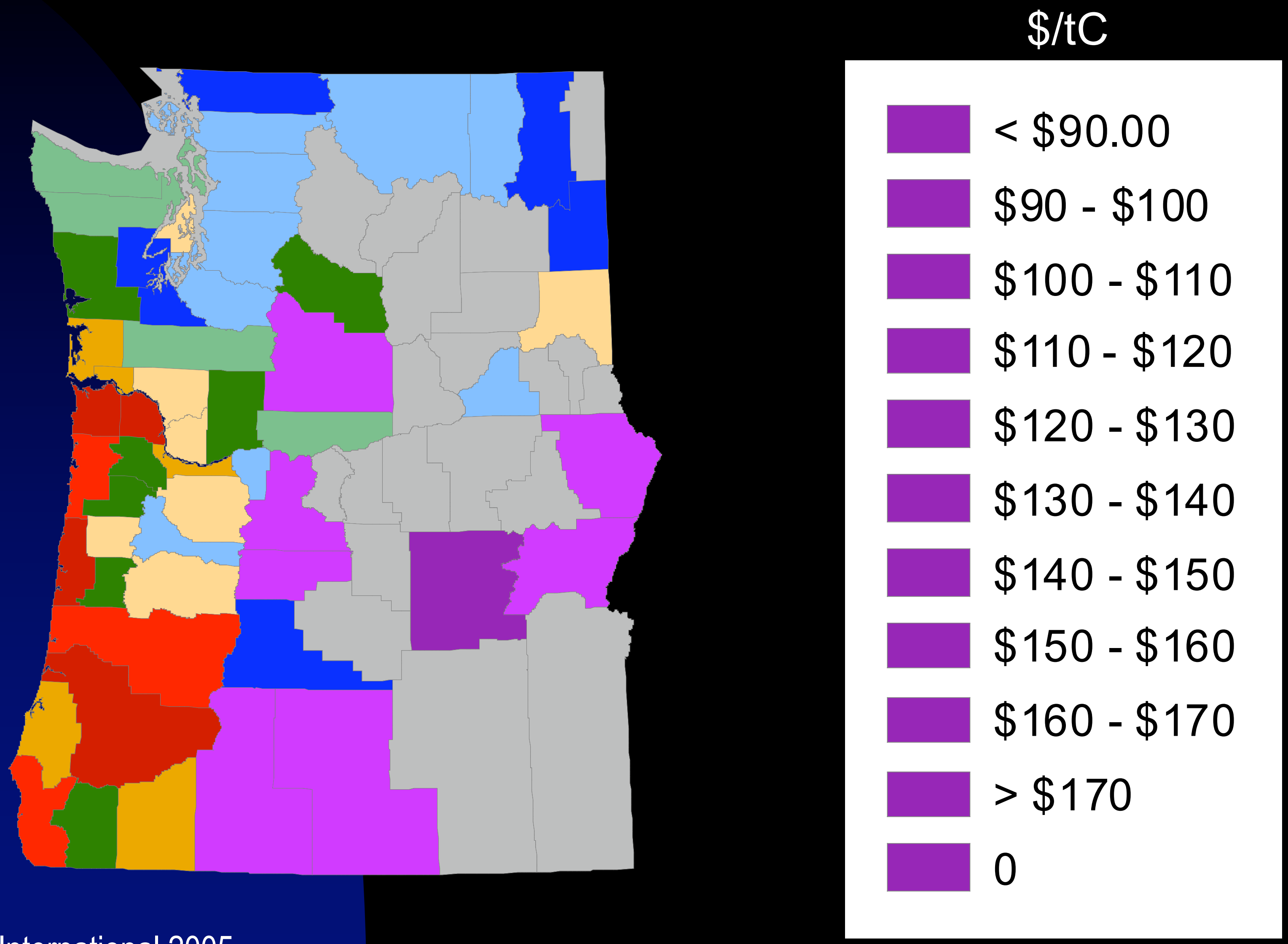
[1] Note that public land omits Federal USDA Forest Service lands.

# Creating 100 ft Riparian Buffers

( Only for lands that are mature or approaching maturity )



# Weighted Areas Average Cost



# Riparian Zone Protection

| | Oregon | Washington | Total |
|---|---|---|---|
| Riparian stream length (million meters) | **26.2** | **23.2** | **49.4** |
| Total potential area (hectares) | **160,000** | **141,500** | **301,000** |
| Mature potential area (hectares) | **8,400** | **14,100** | **22,500** |
| Total carbon (million tons) | **0.34** | **0.61** | **0.95** |
| Average cost per ton ($/t C)) | **$146** | **$122** | **$131** |

# Fuels and Fire Management

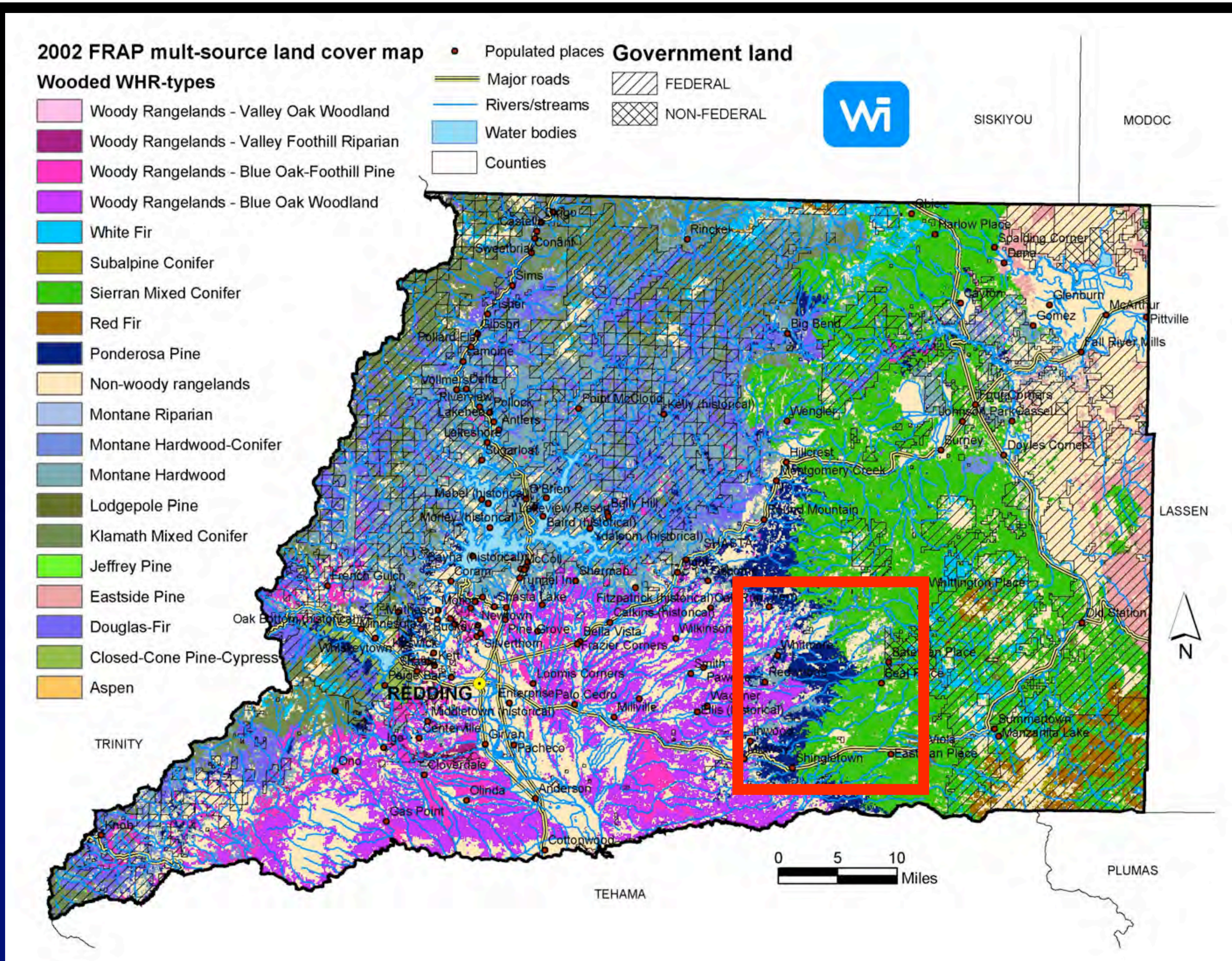
Not all fires
are the same

Source of Photos: Dr. Sam Sandberg, USDA Forest Service PacificWildland Fire Sciences Laboratory

# Potential Sequestration Benefits from Improved Fire Management

Source: Dr. Sam Sandberg, USDA Forest Service PacificWildland Fire Sciences Laboratory

- Reduce net GHG emissions from combustion
- Reduce loss of carbon stocks from large trees
- Reduce loss of carbon stocks from duff
- Maintain carbon accumulation rates during recovery
- Avoid ecosystem-changing fires


2002 FRAP mult-source land cover map
Wooded WHR-types
Woody Rangelands - Valley Oak Woodland
Woody Rangelands - Valley Foothill Riparian
Woody Rangelands - Blue Oak-Foothill Pine
Woody Rangelands - Blue Oak Woodland
White Fir
Subalpine Conifer
Sierran Mixed Conifer
Red Fir
Ponderosa Pine
Non-woody rangelands
Montane Riparian
Montane Hardwood-Conifer
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Klamath Mixed Conifer
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Eastside Pine
Douglas-Fir
Closed-Cone Pine-Cypress
Aspen
Populated places
Major roads
Rivers/streams
Water bodies
Counties
Government land
FEDERAL
NON-FEDERAL
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PLUMAS
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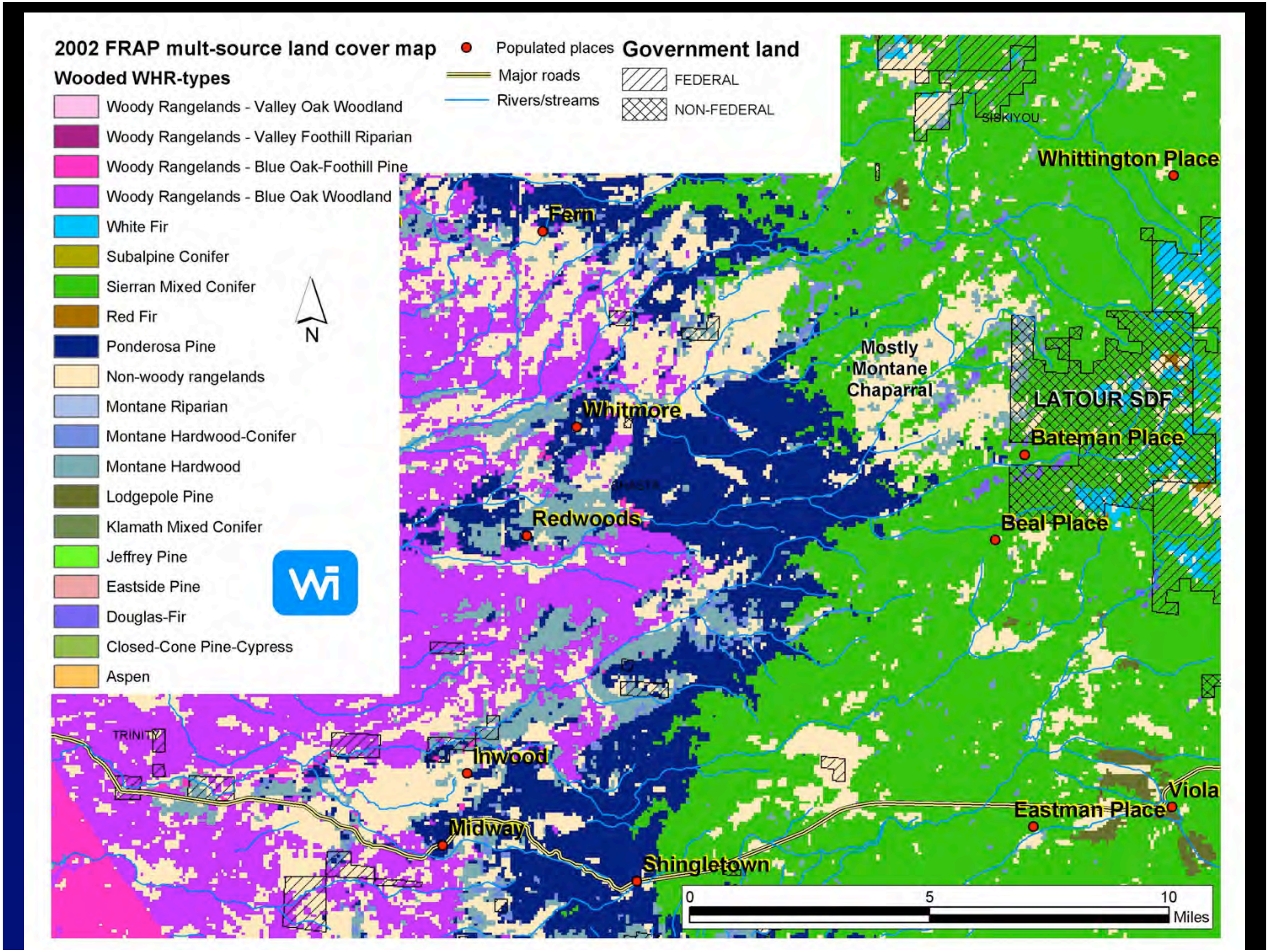
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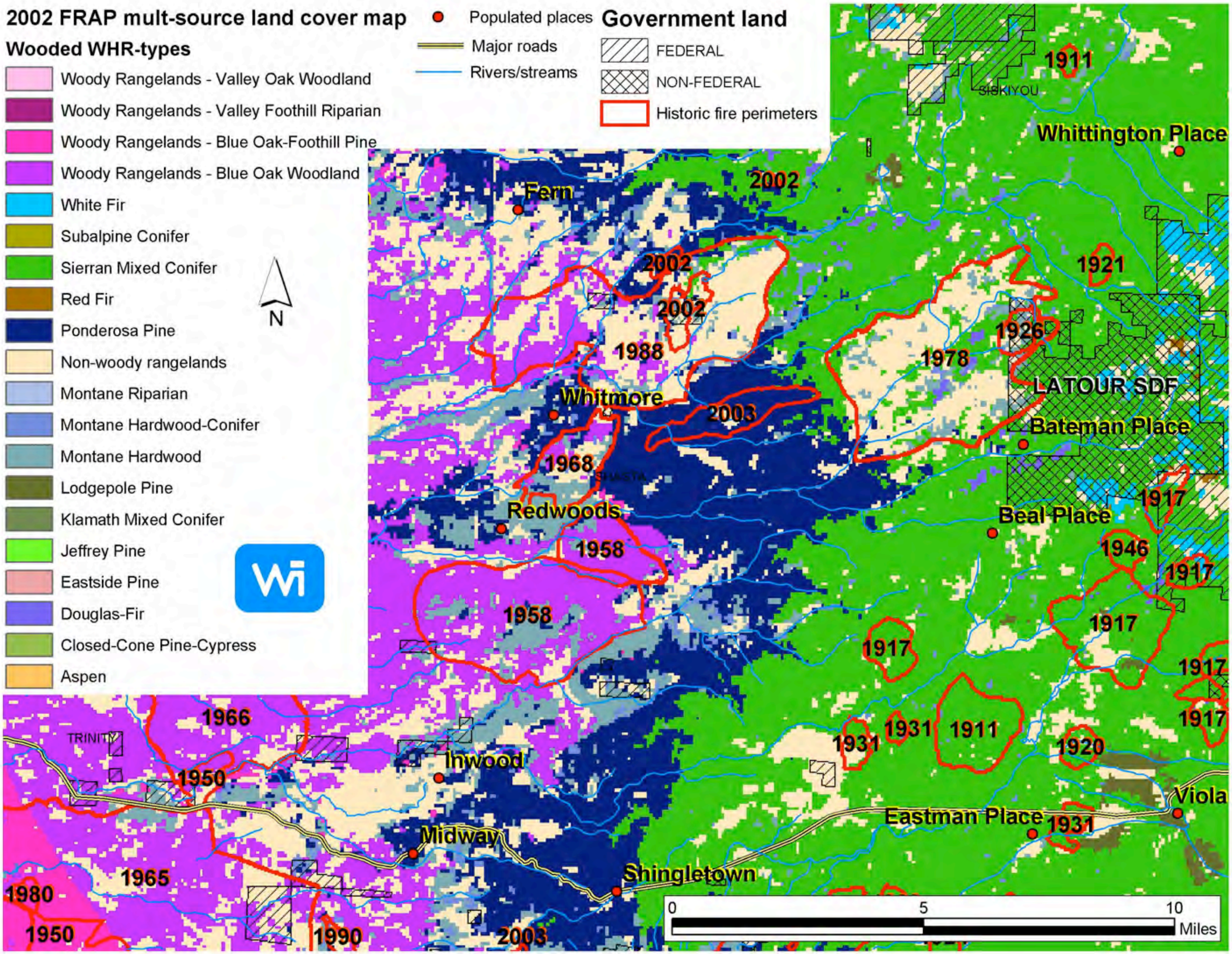
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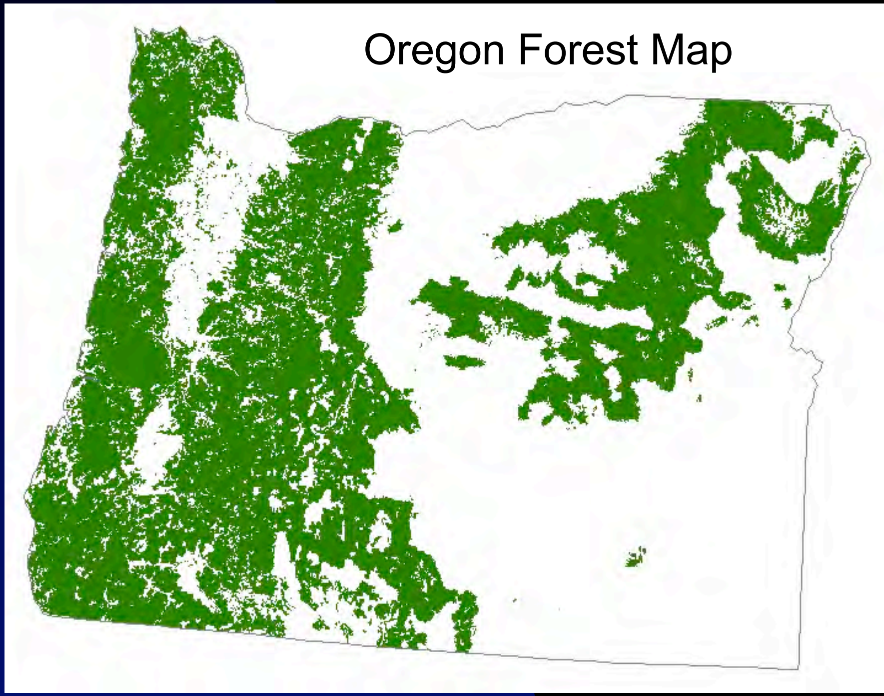
Viola
TRINITY
0
5
10
Miles

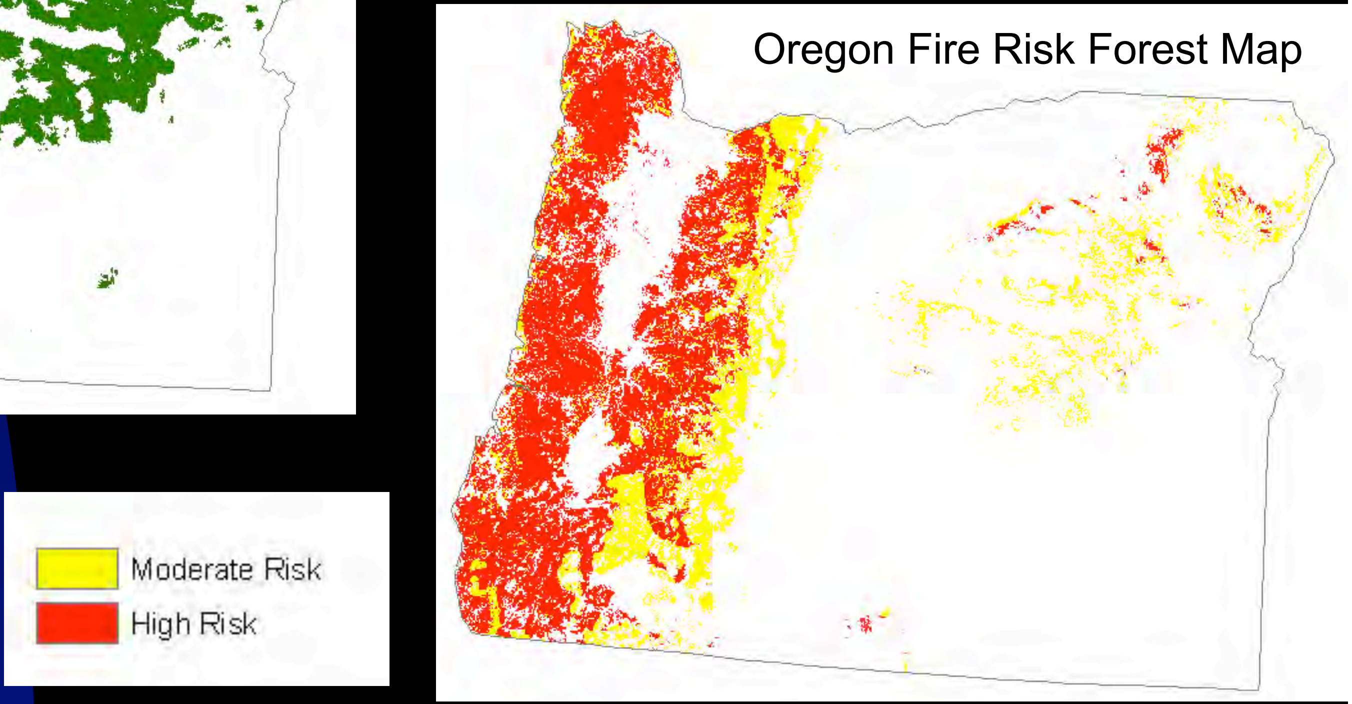
# Ecosystem Conversion

Site of 1978 Whitmore fire in Latour State Forest, Shasta County

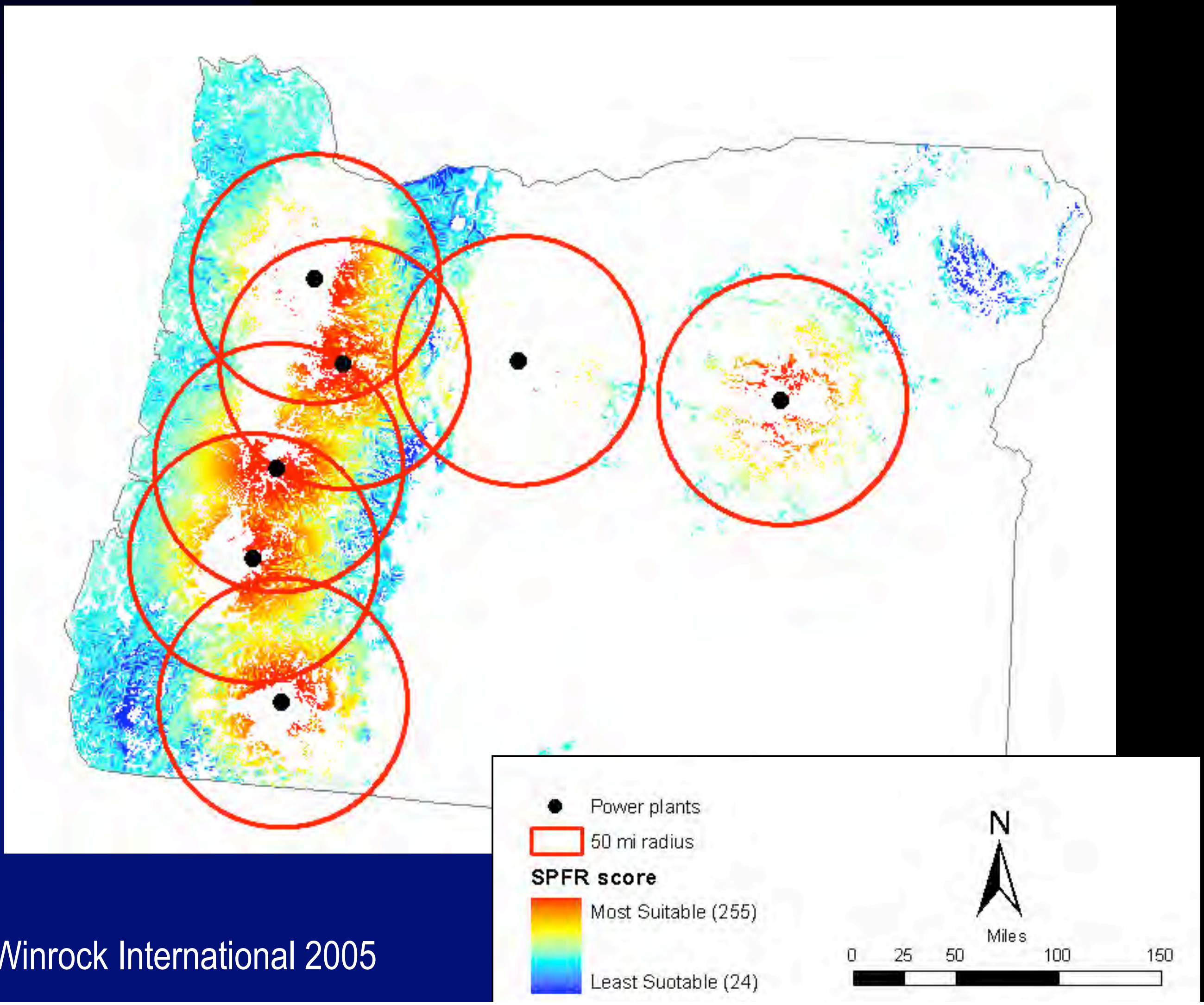
Fire can change forest ecosystems to non-forest ecosystems

# Reducing Emissions from Uncharacteristically Severe Fire



# Estimate Potential Suitability




- Forest area
- Moderate to high risk of fire
- Slope
- Distance from road
- Proximity to power plant

# Potential carbon emissions from fire in California

- Cumulative carbon stocks in forests at high and very high risk for fire with SPFR classes higher than the top 25% (score of 190) = 74.2 million t covering an area of approximately 775,000 hectares
- The estimated net emissions from these forests if they burned could be as much as 22 million t C (range for different forest classes =25-51 t C/ha)

# Conclusions

- Afforestation provides the largest terrestrial sequestration opportunity for Oregon, Washington, and California and can provide sequestration benefits at relatively low costs.
- Potential sequestration from changing fire management practices on forest lands warrants additional data collection and analysis and could be an important element for managing future risks from climate change